VALUE STREAM MAPPING IN A WELDING SETUP

by

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ABSTRACT

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Manufacturing companies are constantly trying to eliminate rework and scrap in the production run. This research looks at a particular process of building a resonator in XYZ company. The whole idea behind the research is to ensure that there is a smooth production flow and identify areas of improvements to reduce scrap and rework of the resonator welding process. Value stream mapping is used these days to eliminate the non value added services and identify areas of improvements. Since the customer does not pay for these non value added services these have to be eliminated for smooth production flow. Using value stream mapping, this research also identifies areas that needed immediate attention to ensure that this production of building the resonator is setup

optimally. This study proposes to develop a current value stream map of the welding of a resonator produced in XYZ plant and suggests improvements that can be used to develop a future state. In order to collect the information for this project, researcher visited the setup several times to first understand the complete production flow. The researcher observed and collected information related to welding process for the mapping from start to finish. Based on all the information gathered, the company may choose to utilize results of this research and the future state map and go lean. XYZ is continually striving to increase productivity and output of their operations. Their goal is to satisfy the customer with the exact product, quality, quantity, and price in the shortest amount of time.

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Chapter I: Introduction

The XYZ Company based in Wisconsin produces Motorcycles and snowmobiles for the rest of the country. One of the parts being manufactured is being produced at the plant where the project is being conducted. The product being studied is production of resonator of these motorcycles. The resonator is assembled and welded together here in this plant. These resonators cost around $115 to be built and they need around 150 resonators built in a day with two shifts running five days a week.

This project addresses the problem faced by the plant due to the huge number of defects and rework with regard to building of the resonator. The project analyzes the current situation during the production of the resonator and provides recommendations based on the problem being faced.

Statement of the Problem

This study is used to develop a current and future value stream map to identify non value added wastes and will make recommendations for improvements. The main problem being faced by XYZ in their resonator production process is a huge amount of rework and scrap rate which results in non value added process to the company. XYZ's current layout is flawed in design, creating another obstacle in the process flow.

Purpose of the Study

This study will help XYZ to reduce costs, improve lead time which in turn will increase productivity and reduce rework. From the data collected on one single day we found that 8 resonators out of 140 produced had to be scraped and another 45 required some form or rework or the other, this was like 32% of all resonator build had to be reworked. If this study was not performed than XYZ will continue losing productivity with increase in rework which is evident in the number of defective resonators being built.

Assumptions of the Study

1. It is assumed that the present state value stream map developed will have all the necessary technical information to enable this researcher to develop a future state map which will help removing the non value added processes by reducing inventory and time.
2. The management is committed in bringing about the changes suggested.
3. The information collected is reliable and accurate.
4. XYZ has the resource and time to implement suggested changes
5. It is assumed that no other changes have been done post collection of this data which would change the present state value stream mapping which will also affect future state value stream.

Definition of Terms

Value Stream: is the set of processes, which includes value-added and non-value-added activities which is required to transform raw materials into finished goods that customers value (Womack & Jones, 1996).

Value stream management: On applying lean management principles to a value stream is called value stream management. (Tapping & Shuker, 2003)

Takt time: is the rate at which a company produces a product to satisfy customer demand. (Tapping, Luyster & Shuker, 2002)

Changeover Time: time taken by the operator at his work station switching the production tools to enable change from one product type to another.

Lead Time: The time taken for parts to be transformed from raw materials to finished goods.

Raw Material: Materials that haven't been changed after being purchased.

Rework: is the required changes needed to be redone to a finished product after it has been assumed to be completed.

Scrap: is the unusable product which followed the regular process of completion but resulted in a being damaged and non usable.

Downtimes: these are regular scheduled breaks; this might include lunch and other breaks. During this time there will be no production at the station with downtime.

Finished goods: products free of any defects and waiting to be shipped to the customer.

Operating costs: monitory costs which the company spends in converting the raw materials to finished goods.

Work-in-progress: product in the production stage which have been transformed from raw materials and in the process of not being a finished product.

Cycle time: The time that elapses from the beginning of a process or operation to its end. (Tapping, Luyster & Shuker, 2002)

Customer demand: the number of products in its finished form needed by the customer.

Kaizen: is a Japanese term meaning "gradual and orderly continuous improvement".

Limitations of the Study

1. This study is limited to be used by XYZ company in its resonator welding process.
2. This study includes current state value stream map which in turn is used to design future state map .
3. This study will provide the future state value stream map which is as accurate to the data gathered in the present state value stream.
4. This study used all the data which was collected for resonator welding process only.
5. Company may accept the proposed current state value stream map and future state value stream map and might do some modifications on them.

Methodology

Using the concepts of lean, which uses Kanban, 5S, and Visual mapping tools such as Current and future state is mapped and the recommendations are provided to XYZ Company. This study was done within the facility of XYZ company to understand the entire flow process which was being performed in the production of the resonator weld process.

During the research work all information on existing processes, number of people and each step where followed with their respective cycle times and waiting times in each step. The information was collected by interacting with station workers on the floor. Using all these information a current value stream map was drawn showing the entire communication flow and using this and identifying areas that need to be eliminated, a future state value stream mapping is also constructed.

Chapter II

Literature Review

Introduction

This literature review will touch upon a brief introduction to key concepts of Lean that needs to be taken into account during value stream mapping process of both present and future state which this research is trying to address.

"Lean" is a system that uses fewer inputs to create the same outputs rather than those created by using mass production system. (Womack, Jones, & Roos, 1990). Lean gyrates towards eliminating wastes in its process by trying to achieve the shortest possible cycle time. Lean decreases the total time from when the customer places the order and the actual shipment to the customer. This manufacturing process increases profitability, customer satisfaction and throughput time.

Traditional manufacturing companies maintain large inventories of supplies, parts, subassemblies, space, warehousing resources, and backup in order to meet all production contingencies. Various production stages produce in lots which are not coordinated with other stages. This leads to inefficiencies because stages can get out of sync, because stages are not responsive to one another, and because resources are tied up in excess inventory.

Cost reduction principle:

Customers tend to demand highest quality at the lowest possible price with reduced lead times. From the past thinking of cost plus profit model which was how companies thought of being successful to the present when reduction of costs by eliminating wastes in the system will see higher profit margin for companies.(Tapping, 2002). Value stream mapping will deliver the profits required by ensuring the resources are committed in the correct places and in the right directions.

Seven deadly wastes:

Lean aims at elimination of all wastes (muda) which adds unnecessary costs and time without any additional value. Theses seven deadly sins are

1. Overproduction: ones produced which are not intended to immediate use/sale.
2. Waiting : idle time between operations
3. transport: poor layout causing materials to be moved about unnecessarily
4. Overprocessing: doing more to the product manufactured than necessary
5. Inventory: excess stock in form of raw materials which are in work-in-process
6. Motion: any motion that is not necessary for successful completion of operation.
7. Defects: defective goods or mishandled materials.

Toyota Production System (TPS)

TPS was developed by Taiichi Ohno during World War II for Toyota Motor Corporation.

The two pillars of TPS are:

1. Just-in-time (JIT)
2. Jidoka (autonomation)

1. Just-in-time (JIT)

Lean manufacturing is also called just-in-time. The conceptual model for this process is a single, long, continuously moving conveyor belt that runs from the first production station through delivery of a finished product. Each stage produces just enough material for the next production stage. Lean manufacturing makes production more efficient because it eliminates excess inventory and time lags between various manufacturing stages. More importantly, this production cycle leads to efficiencies because it is designed to coordinate all operations and prevent workers from ignoring production problems to make this coordination possible.

2. Jidoka (Autonomation)

This being the second pillar of the TPS is the use of automation to have zero defects and not pass on a defective productive downstream. Jidoka tries promoting free flow within a JIT system. This is accomplished slowly, systematically and inexpensively. Three main functions of Jidoka are to

1. Separating human performed work from machine work
2. Developing defect-prevention devices
3. Applying Jidoka to assembly operations.

5S System:

5S is huge prerequisite for implementing any improvement method. 5S teaches everyone the principles of improvement, starting place to eliminate waste, removing obstacles which hinder improvements and give workers control over workspace.

5S are:

1. Sort: sorting and removing contents in area which are unnecessary
2. Set in Order: arranging in such a way that it is easy to access and keeping it that way
3. Shine: keeping things clean and ensuring all equipment and area are maintained that way
4. Standardize: creating guidelines and making those visual and obvious.
5. Sustain – educating others and communicating this to everyone to follow and obey.

Three main stages of Lean applications which are Demand, Flow and Leveling:

1. Demand stage: identifying the exact customer demand for products being manufactured taking into account quality, lead time required and hugely the price.
2. Flow stage: enforcing clear and smooth flow throughout the plant so that both internal and external customers benefit from the right product, quality and time.
3. Leveling : this is done by ensuring work gets distributed evenly, so that this reduces inventory and work in progress.

Components of Lean Manufacturing

Lean Manufacturing uses the following:

a.) Just-in-time: station uses only what is required and when it is required.

b.) Standardized production: this involves setting, documenting and maintaining standards for all major areas of production.

c.) Continuous cost reduction: this is done by kaizen or continuous improvement.

d.) Flexible work force: due to the fact that lean manufacturing doesn't use standby workers, it requires cross training of workers as they can take on various tasks and act as a backup.

Kaizen

Kaizen is a culture of sustained continuous improvement focused on eliminating wastes in all systems and processes of an organization. Kaizen implies on constant evolutionary and gradual improvement rather than revolutionary changes.

Process improvement occurs through the following stages:

1. Production strictly observes all procedures
2. Production is constantly measured
3. Line employees and team leaders provide input to process refinements
4. Incremental changes are documented and put into practice
5. The impact of these changes is measured and evaluated.

Kaizen is based on making little changes on a regular basis, always improving productivity, safety and effectiveness, and reducing waste. Kaizen involves setting standards and then continually improving those standards. To support the higher standards Kaizen also involves providing the training, materials and supervision that is needed for employees to achieve the higher standards and maintain their ability to meet those standards on an on-going basis.

Takt Time:

It is the available weekly work time, taking into account the shifts worked and making allowances for planned stoppages (for planned maintenance, team briefings, breaks) divided by the anticipated average weekly sales rate (including spare parts) plus any extras such as test parts and anticipated scrap.

Takt time = Available time / Customer demand.

Example: If your customer requires 100 resonators a day, the

$$= \frac{7\,\frac{1}{2}\text{ hours}}{100\text{ units}}$$

$$= \frac{7.5 \times 60\text{ minutes}}{100\text{ units}}$$

$$= 4\,\frac{1}{2}\text{ minutes}$$

resonators needs to be done/delivered every 4 ½ minutes (or multiples of it). To smooth out variations in process time within the operation Kanbans, multiple machines and flexible labor can be used.

Using the Takt time

1. Calculate your demand i.e. what does your customer typically want every day/week/month.
2. Calculate your available time = working time – regular 'non-direct' time

   (non-direct time = stand-up meetings, breaks, cleaning etc)

1. Calculate your Takt Time.
2. Compare current operator cycle time against Takt Time using a bar chart.
3. Identify steps to rebalance work and, if necessary, adjust the number of operations so each employee has a full job, passed to Takt Time. Thus avoiding the build up of WIP or waste due to waiting.
4. Consider the inputs you receive to do your work and take steps to adjust these to match Takt Time.
5. Regularly (each week in most cases) recalculate your Takt Time to ensure it reflects current circumstances, and adjust manning levels accordingly.

How Takt time helps

- Essentially it provides a rhythm for the work and thus stabilizing the production
- Immediate feedback on performance is a powerful motivator and Takt Time allows a team to be more aware of output rates and potential problems.
- For processes and machines, working at the Takt Time may mean slowing down. This can actually lead to a reduction in lead time!! This is because queues build

up after machines that run faster than the Takt Time i.e. try and get all machines in a plant running at the constant Takt Time.

Value Stream

This is defined as the set of processes which includes both value-added and non-value-added activities which is required to transform raw materials into finished goods that the customers value (Womack & Jones, 1996).

Value stream is defined by its customers in some cases the companies themselves identify the entire value stream for each product or each product family (Tapping, Luyster & Shuker, 2002).

Value stream Management

Value stream management is a process for planning, managing, and linking lean initiatives through systematic data capture and analysis (Tapping, Luyster & Shuker, 2002). Value stream management consists of the following critical steps:

a.) Commitment to go lean

b.) Choosing value stream,

c.) Learning all about lean,

d.) Mapping of the current state

e.) Determining all lean metrics

f.) Mapping the future state,

g.) creating Kaizen plans,

h.) Implementing Kaizen.

Value Stream Mapping

Value stream mapping is a visual tool that shows the actual flow of information and material as the product makes its way through its production stage. (Rother & Shook, 1999). Value stream mapping of the present stage is represented first before a future state recommendation is presented. Mapping the activities with down times, cycle times, and process inventory will help visualize the current state and help make recommendation for future state.

Value stream mapping can show the picture on how the current state really is and the future mapping shows area that needs continuous improvement.

Value Stream Mapping helps:

- Visualize more than just the single-process level.
- helps see more sources of waste in your value stream
- acts as a common language for talking about manufacturing processes
- it makes decisions about the flow apparent, so you can discuss them
- it ties together lean concepts and techniques helps you avoid "cherry picking"
- it forms the basis of an implementation plan
- it shows the linkage between the information flow and the material flow
- it is much more useful than quantitative tools and layout diagrams that produce a tally of non-value added steps, lead time, distance traveled, the amount of inventory, and so on.

Chapter III:

Methodology

This research uses qualitative method to suggest ways to reduce the total time in the production of the resonator. This research was chosen from a group of projects identified by XYZ company which needed improvements. The researcher for this project visited XYZ several times to collect information on the flow of materials from one station to another and from one operator to another, along with the inventory stored between the processes.

This research will try to suggest ways to reduce rework and scrap in building the resonator by mapping the exact flow of materials from one station to another. They also have a problem with their current layout.

The entire process from start of assembling the resonator to the end of actually producing this, there is constant rework and rejection of internal parts for the actual production of this resonator.

The actual layout of the production is actually is not free flowing with the requirement for the manual welder in line to actually drive around to go pick up the finished robot welded baffles and perforated tubes and there is two separate drive required to pick this product.

The researcher used the following solutions in suggesting ways to reduce the rework and scrap of the resonator:

a. Pareto charts
b. Current Value stream
c. Takt time
d. Redesign of layout
e. Quality checks and redesigning the internal components.

a. Pareto charts:

XYZ had already developed an instrument to identify the areas that had constant rework and this was given to the operator who performed the final check on the resonator by checking the appropriate area that had the defect/rework.

(The figure 3, shows the sample used)

b. Current Value stream:

The researcher followed the flow of material by mapping the product and information flow from one station to another and from one operator to another. The inventories between the stations were also noted.

A visual diagram of the current state of the value stream is mapped.

c. Takt time:

The researcher suggests how the takt time can be calculated for the production run as currently no takt time existed and this is needed to be calculated.

Following is the equation used to calculate takt time

Takt time = Available time / Customer demand.

d. Redesign of layout:

This problem was identified visually and this was an immediate requirement for change which the operators and the supervisor acknowledged. The flow of materials was not smooth due to the robots and the weld operators in disrupted direction. The researcher followed this process, identifying the time used to transfer the finished material from one station to another and the visual methodology used to represent this.

e. Quality checks and redesigning the internal components of the resonator:

The researcher on walking through the process and communicating with the operators in various stations found a huge amount of internal parts which were inferior in quality which resulted in huge wastes because it was unusable and a whole lot had to be rejected just because the entire batch used to fail to meet the operators expectations.

Chapter IV

Results

The main purpose of this study was to reduce the overall rework and scrap costs of building a resonator by mapping out the current value stream and identifying the areas that needed immediate attention.

Pareto chart:

The data instrument sheet collected is used to construct the Pareto chart and this graph is analyzed. Pareto chart helps us analyzes 80% of problems that usually stem from 20% of the causes. (Tapping, 2002). Pareto charts are used to display the Pareto principle in action, arranging data so that the few vital factors that are causing most of the problems reveal themselves. Concentrating improvement efforts on these few will have a greater impact and be more cost-effective than undirected efforts.

Person who conducts the final tests on the weld resonator is given this instrument. We collect these data for all resonators being produced for a period of time and plot the graphs of the data collected. On doing the actual count of the data we can narrow down the majority of causes of the rework in welding and we can retrace steps backwards. (An example of data instrument sheet collected is shown in fig 3.)

From the data generated in the Pareto chart. We might find two or three categories will tower above the others. These few categories which account for the bulk of the problem will be the high-impact points on which to focus. If in doubt, we will follow these guidelines:

1. Look for a break point in the cumulative percentage line. This point occurs where the slope of the line begins to flatten out. The factors under the steepest part of the curve are the most important.
2. If there is not a fairly clear change in the slope of the line, look for the factors that make up at least 60% of the problem. (Tapping, 2002). You can always improve these few, redo the Pareto analysis, and discover the factors that have risen to the top now that the biggest ones have been improved.
3. If the bars are all similar sizes or more than half of the categories are needed to make up the needed 60%, try a different breakdown of categories that might be more appropriate.

Often, one Pareto chart will lead to another:

- before and after charts
- charts that break down the most important factors discovered in an earlier chart

Process and current value stream map:

This researcher followed the process flow through the floor where the resonator was being built and made a note of the inventory and other areas of concerns by discussing with the operators working the stations. A flow chart is prepared showing the material flow and information flow for the entire resonator built process.

Using the flow chart and various other data collected a current state map is prepared; the visual diagram of the entire operations is shown in figure 5.

Following is the process that this weld-resonator goes through on the floor, this researcher followed this entire cycle:

1. Internal baffles are welded by robot
2. Perforated screen halves are welded together by robot
3. Mounting brackets are welded manual for the gap since the robot cannot make the angle.
4. Internal baffles and perforated screen along with the mounting brackets are welded
5. One shell is taken and the baffles and perforated screen are inserted along with the piece insulation for welded into the shell.
6. Opposite piece of the shell is inserted and the are welded
7. First spot welding is done at various points of the joined two shells
8. Seam welding is done on the joined two shells
9. Lastly the rapid fire is used to complete the joining of the shells

10. Welding is done on the cutouts of the shells to close the gaps on the shells on both sides
11. Cabs are welded onto the shells
12. Mounting brackets are added on the shells
13. Finish welding is done on both outward and inlet value
14. 6 psi of air is inserted and the ends of the tank sealed of and then the tank is inserted into the water to check for defects. Incase the defects are present , taken out and welded by the person checking for defects, in case the defects prevail after welding various points , the tank is scrapped
15. In case this passes the test, the tank is finished for cosmetic purposes and packed for delivery.

Conclusion

The above information collected resulted in this project, the current value stream map for XYZ company as shown in figure 6 was one of the results of this project along with the future state value stream drawn using the current value stream as a bench mark for improvement. The current value stream map allowed this researcher to narrow down where waste occurs in the process and will help make recommendations based on these observations in chapter 5 and is shown in the future state map as well.

Chapter V

Discussion

The purpose of this study was to suggest ways to reduce rework and waste in the weld-resonator building process. By using Pareto charts, 5S, and value stream mapping we can analysis which area needs to be identified as potential areas of improvements and this can be used to reduce the overall waste in the system.

Observations

On following the cycle of the weld resonator from start to finish, or total product cycle time was 90 minutes. The time taken from raw materials to finished product was around 17 days which is the total lead time. The non value added activities is the difference between the total lead time and total product cycle time which is the time the customer doesn't pay for. Hence we can convincingly say that the entire process can be improved.

On visual observations on the floor and by talking to various station workers it was clear that in each process there was huge amount of rework being done, this coupled with the fact of the layout of the whole setup. The layout was flawed in design as the flow of product from the robot station to the manual welder was hindered. Manual welder in line after the robot weld had to physically use a hand cart to wheel the finished product from that station to the station he was working on. There was no visual aid in place to know when the products were completed; this caused a lot of wait on the down stream.

The brackets which needed to be welded could not be done on the robot due to design flaw and hence it took an additional worker to do the work of what the robot could have done in one instance and this adds to the non value added time for production.

As this researcher went through each station he found defects at every point and huge amount of inventory at each station. This clearly shows that the process is no where close to being lean. The other glaring observation was for the rapid and spot welding machine setups where each operator had an entirely different setup which resulted in variations and quality of welds.

The other observations found were that the shells on the resonator were never consistent and overall very thin and didn't sit well in the grove that needed to be welded and hence adjustments had to be done to accommodate this. This affects the overall quality of the product.

The huge inventory pile up in each stations showed the huge amount of inventory costs tied in which meant that less funds to redesign or reengineer. The common problem was waiting of finished parts to move to the next station which was due to lack of kanban or visual methods and also due to poor communications from one worker to the other.

The entire floor were filled with inventory of both good and defective parts and this ensured that there a huge opportunity to go lean in the system by identifying the areas. Using the current value stream mapping of the process and coming up with the future value stream map will enable XYZ to go towards being lean.

Recommendations

From this research, it becomes very clear that there is a huge scope for improvements in the complete production of the resonator.

As the entire process from start of assembling the resonator to the end of actually producing this, there is constant rework and rejection of internal parts for the actual production of this resonator. The work done by the robot needs constant rework as the job is not perfect. This is the first step towards eliminating rework in the production cycle.

The other problem that needs to be looked into is with main shells which don't usually line up just right making it harder for the assembled products to align perfectly, this results in bad welds and as a result of which have a larger chance of being rejected due to inability to any rework that might fix the problem.

As the welding setup is being constantly changed to accommodate for the perfect weld depending on the thickness of the shells, there needs to be a documented process on what the exact steps needs to be followed during the seam and rapid welding process for optimal results as each operator keeps changing this setup depending on his/her comfort level.

Since the actual layout of the production is not free flowing , with the requirement for the manual welder in line to actually drive around to go pick up the finished robot welded baffles and perforated tubes and there is two separate drive required to pick this product. This researcher suggests with changing the current layout to accommodate the free flowing cycle or by providing a conveyor belt option. If XYZ finds this difficult to do they will need to create a good Kanban system that will facilitate better coordination between the robot stations and the next station which at present is totally uncoordinated and depends on the inventory levels.

Currently no takt time is been established for the process and XYZ will need this to be done as this provides a good rhythm for work and allows for greater stability in the process. This also provides an immediate output rates and potential problems that can be addressed, which otherwise might go unnoticed and get built up.

Using the researchers proposed current value stream and future state map XYZ will be able to visualize the improvements that can be achieved and the overall improvements can be a huge financial gain for the company.

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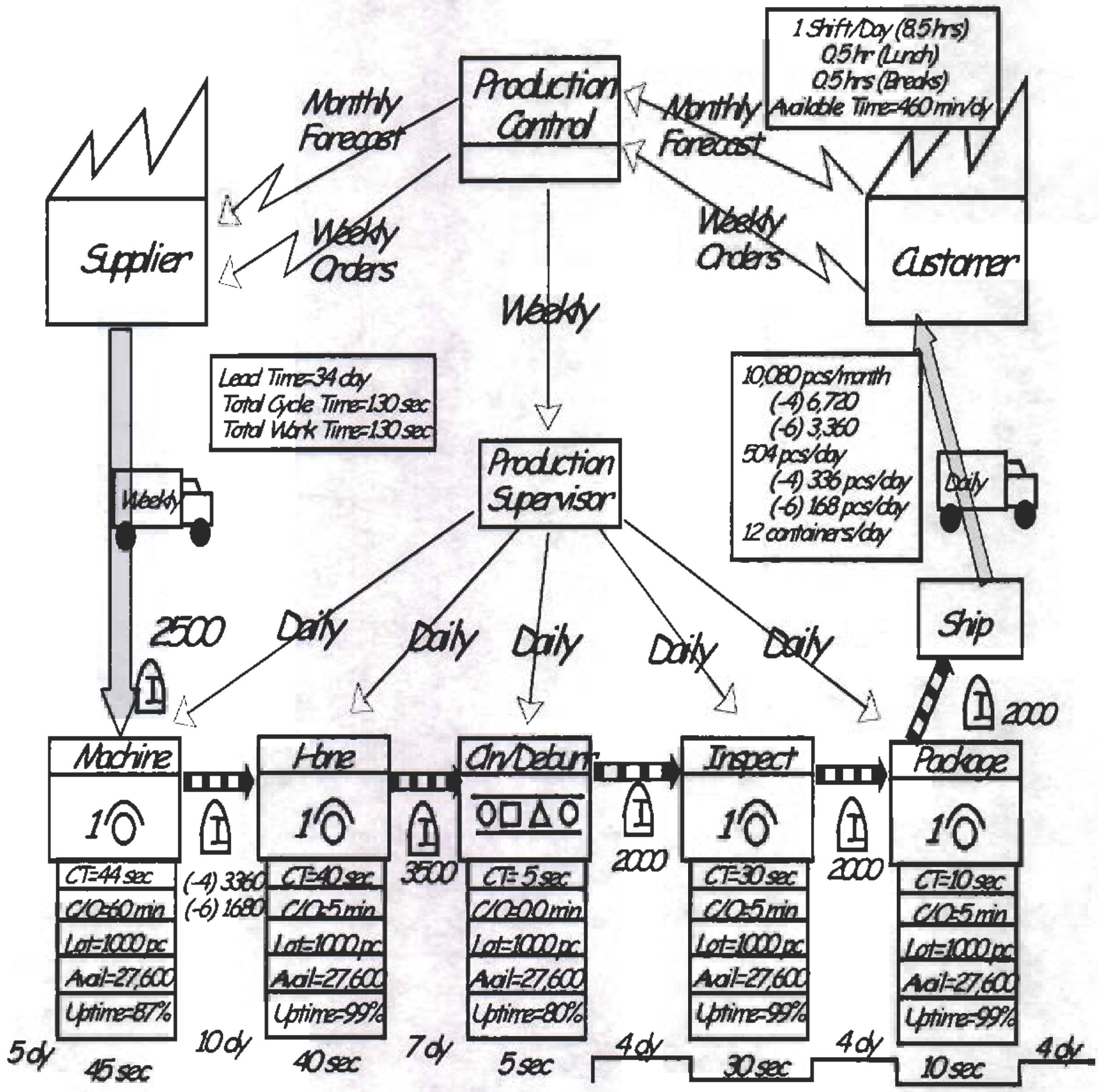


Figure 1. Value Stream Mapping

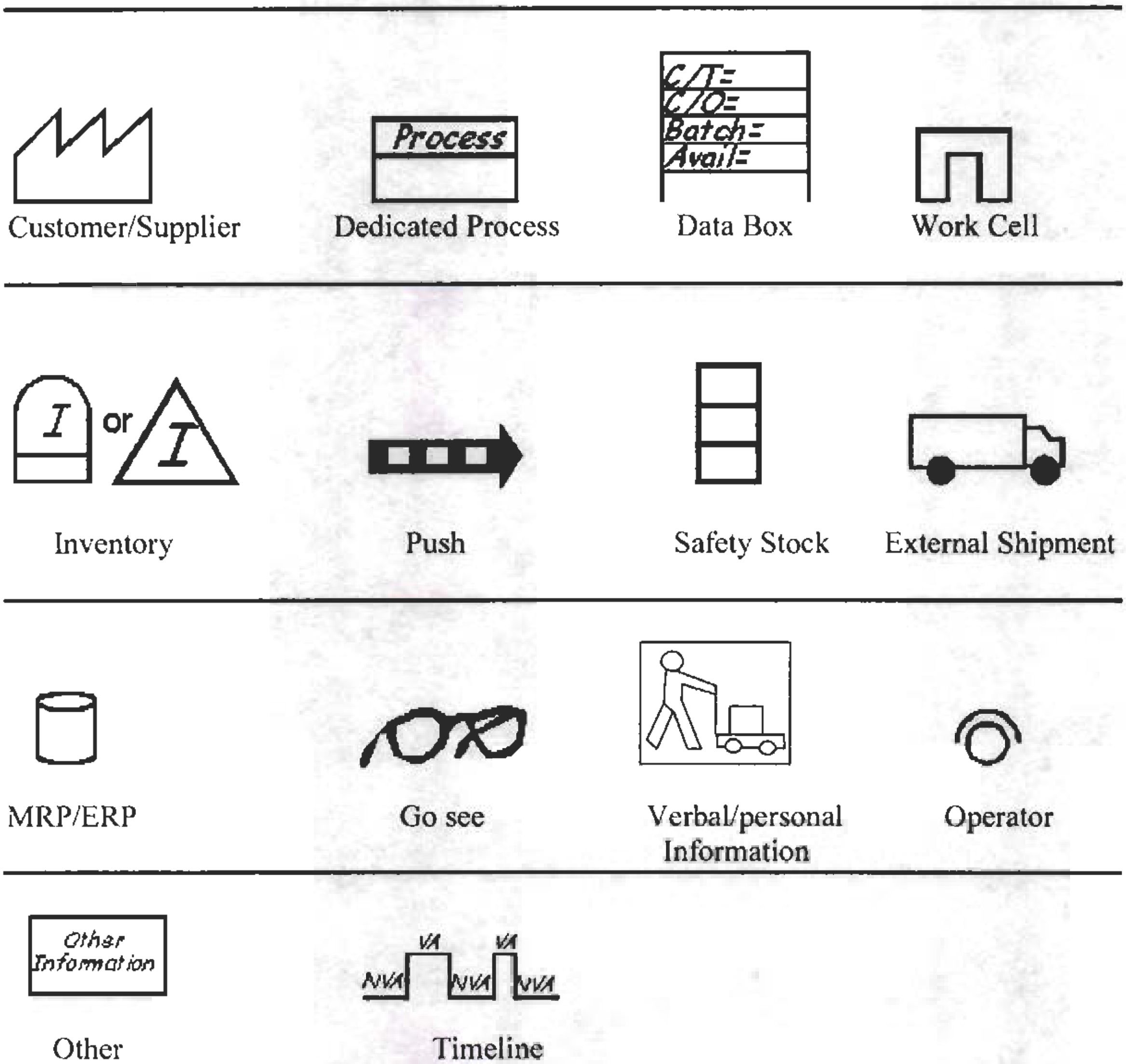


Figure 2. Value Stream mapping symbols

FIRST TIME QUALITY - RESONATORS

PART NO#	DATE:
EMPLOYEE NUMBER	
COUNT	

Please mark on the box when a leak/hole/b ad weld occurs

TYPES OF LEAKS/BAD WELDS	
Holes/Leaks on end caps	
Holes/Leaks on down seam	
Holes/Leaks on outlets	
Holes/Leaks on cleanout	
Holes/Leaks on Brackets	
Holes/Leaks on hooks	
Holes/Leaks on spot welds	
Bad welds on brackets	
Bad welds on hooks	
Bad spot welds	

Fig 3: Sample of the instrument used to collect rework data

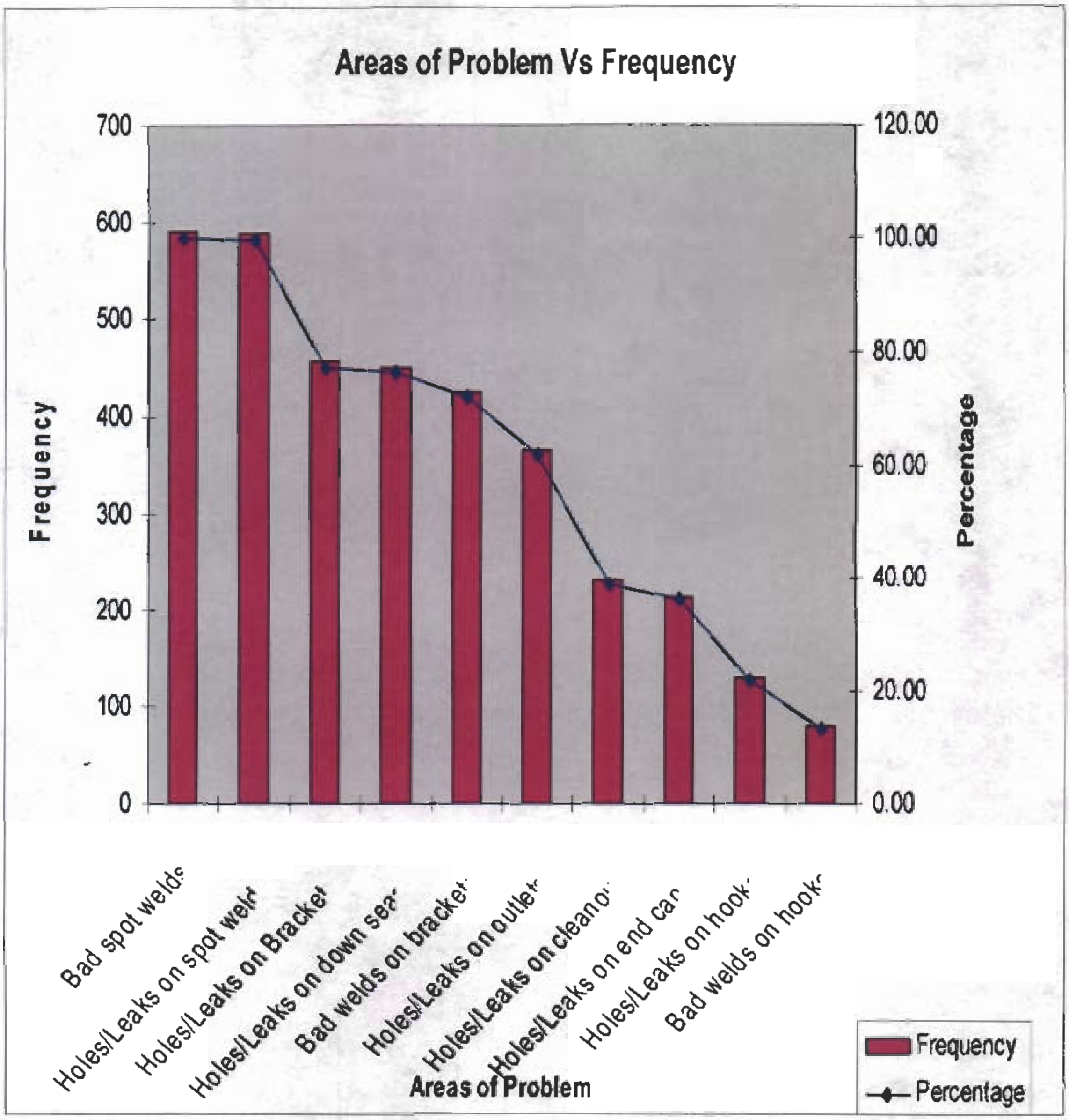


Fig 4: Pareto Chart on a sample data conducted on the floor

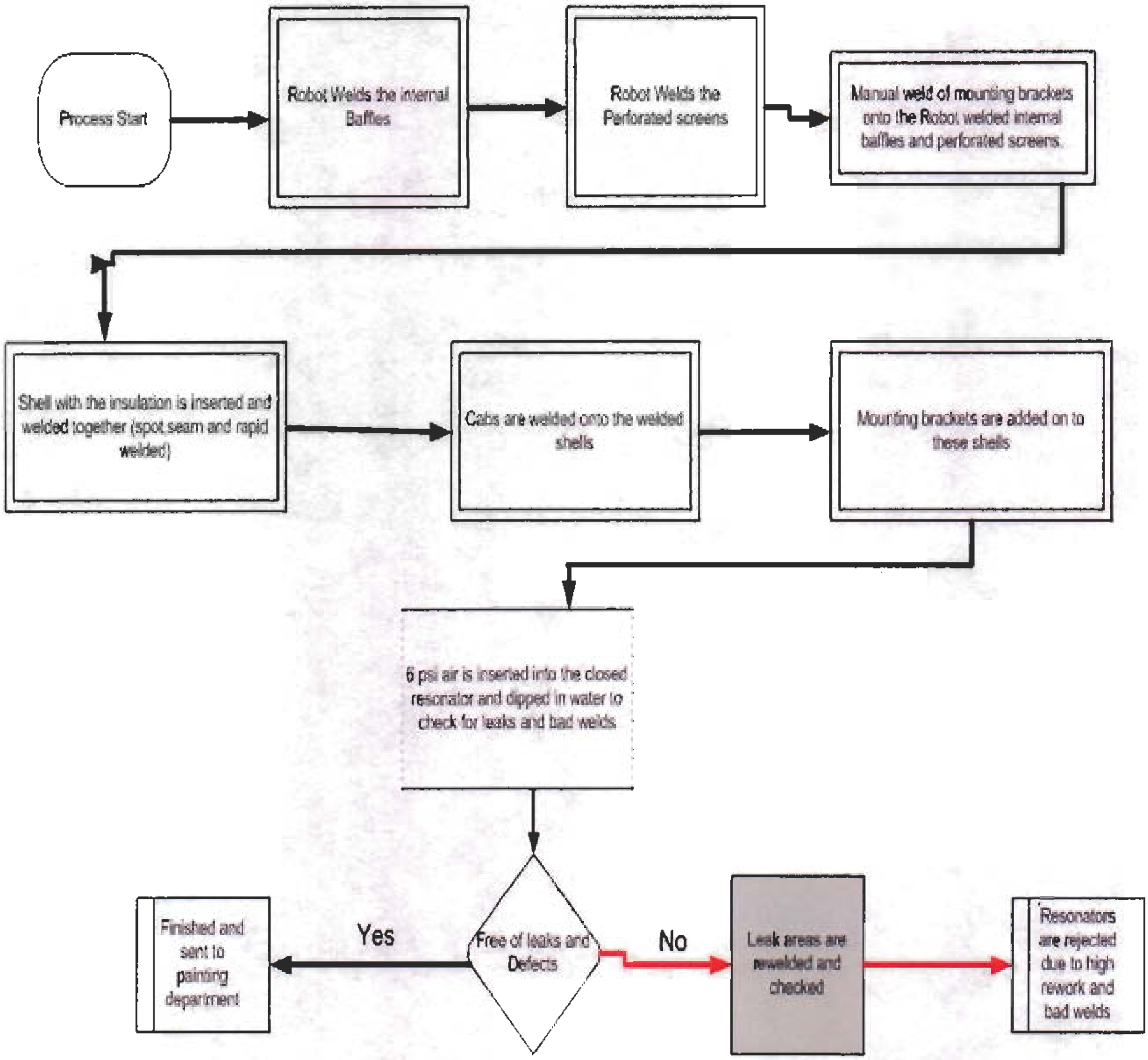
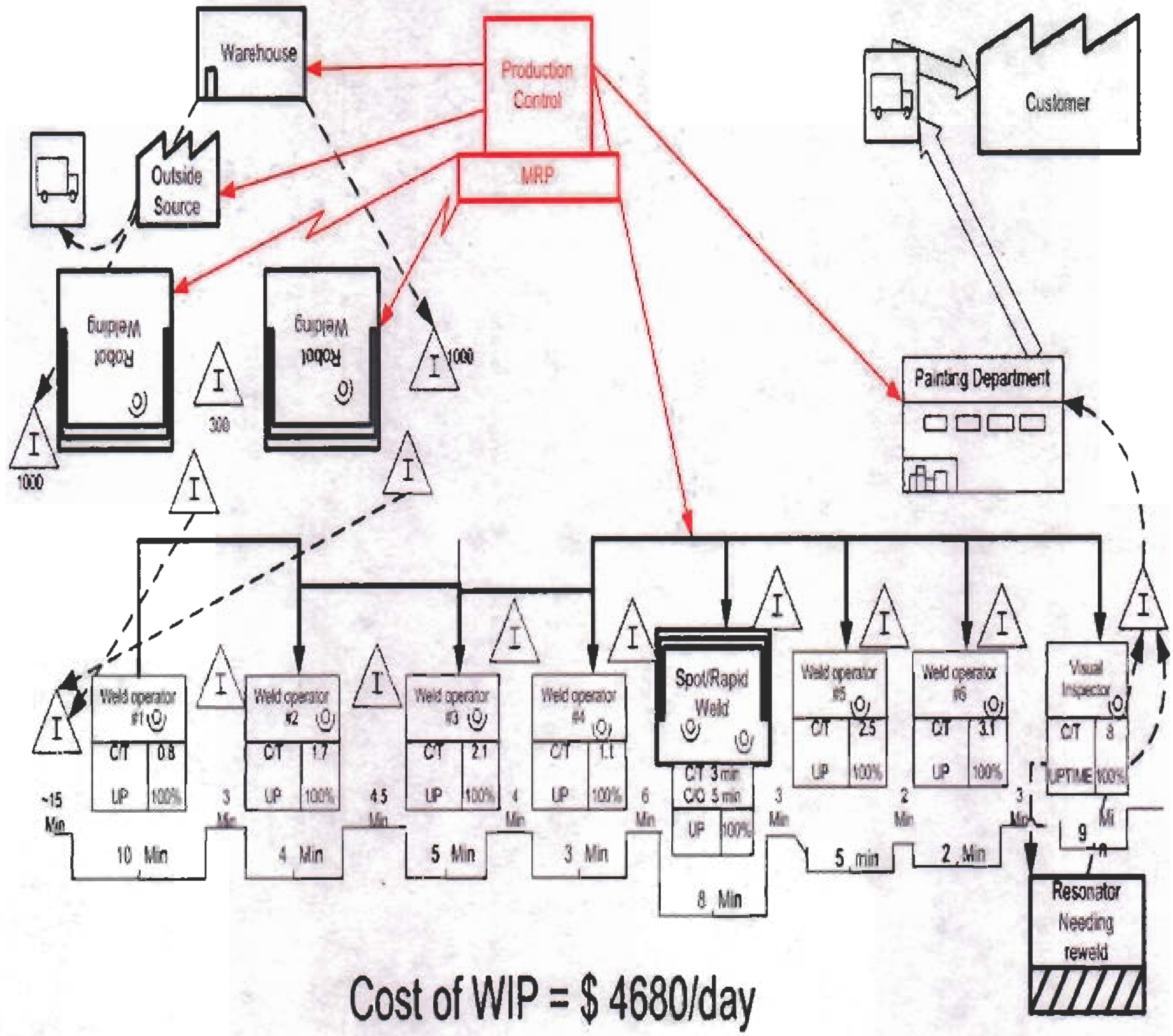


Fig 5: Flow chart of the weld resonator process



Current State Value Stream Map
Weld resonator

Fig 6: Current State Value Stream mapping of Weld Resonator

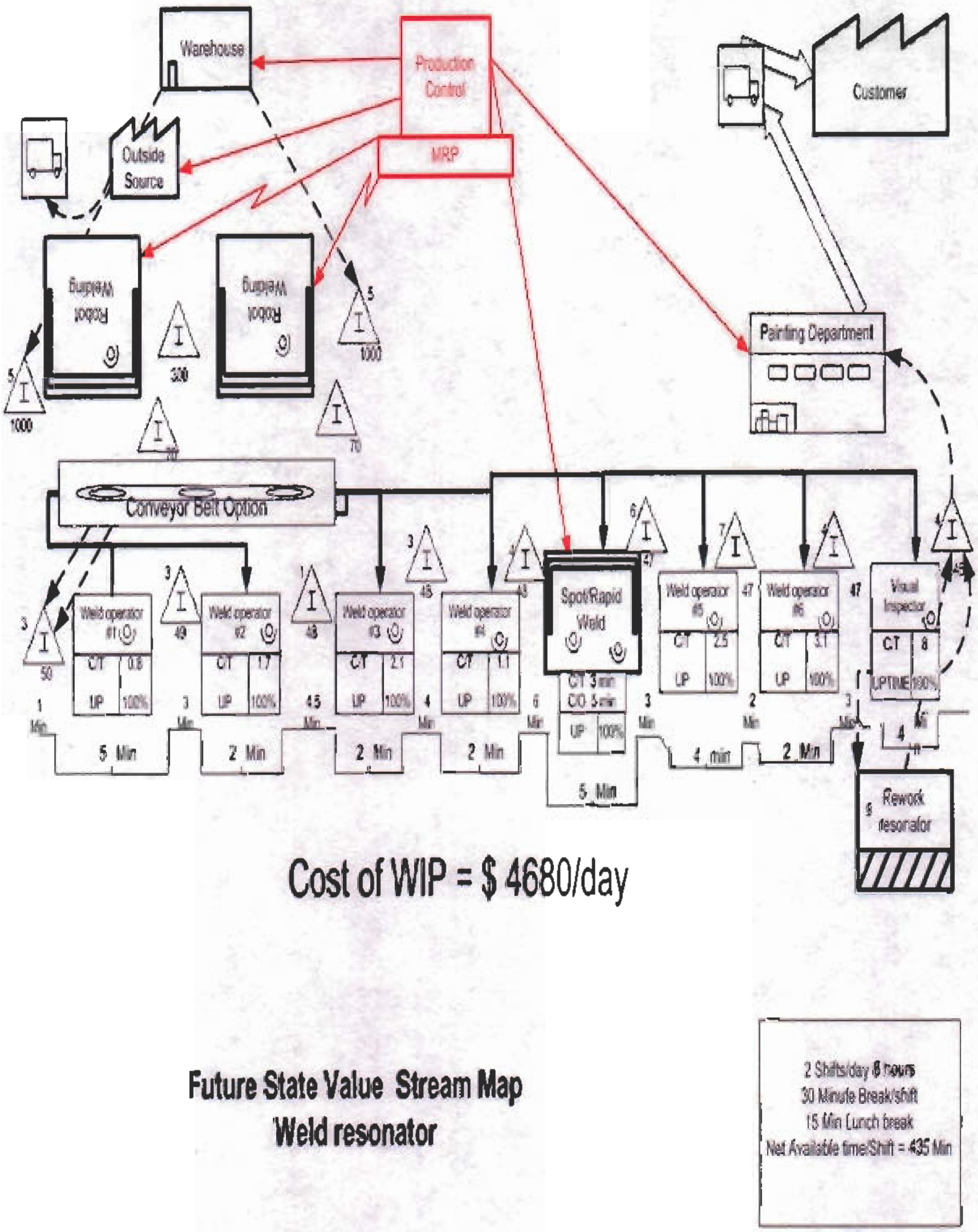


Fig 7: Future State Value Stream Mapping of the weld resonator